

channel with 0.01 ppm>TDS boiling fluid<5 ppm for at least 1000 hours with 5% or less (preferably 2% or less) change in outlet temperature on adjacent process microchannel; Partial boiling process in a microchannel with 0.01 ppm>TDS boiling fluid<1 ppm for at least 1000 hours with 5% or less (preferably 2% or less) change in outlet temperature on adjacent process microchannel; Partial boiling process in a microchannel with 0.01 ppm>TDS boiling fluid<15 ppm for at least 100 hours with 5% or less (preferably 2% or less) change in outlet temperature on adjacent process microchannel; Partial boiling process in a microchannel with P>100 psig for at least 1000 hours with 5% or less (preferably 2% or less) change in outlet temperature on adjacent process microchannel; and/or Partial boiling process in a microchannel with <50% boiling for at least 1000 hours with 5% or less (preferably 2% or less) change in outlet temperature on adjacent process microchannel;

[0157] In any of the aspects in the paragraph above, the boiling fluid comprises at least 0.01 total dissolved solids (TDS), unless otherwise specified.

[0158] In another aspect, the invention provides a process for partial boiling in a microchannel where the SR number is less than about 0.001 for a microchannel length of 4.0 inches or more.

[0159] The invention can further be characterized as a partial boiling process to maintain the temperature variation in an adjacent process channel where exothermic reactions take place at less than 5% above the process inlet stream temperature (K, absolute temperature scale). Or where there is a reduction of temperature rise in the process side of more than 50% with comparison to single phase convection heat transfer (K, absolute temperature scale).

[0160] The invention also includes the use of a microchannel to conduct stable, partial boiling heat transfer (per the definition given in Example 3) in a channel that has a channel length to hydraulic diameter ratio equal to or exceeding 1000 and a length of 15 cm or greater.

[0161] The invention also provides a method of partial boiling in a microchannel where the overage temperature ($T_w - T_s$) equal to or less than the following function

$$56353 \times Bo + 1.4315$$

from $Bo = 1.0E-06$ to $1E-04$, for 3 or more channels when each channel's length is L is greater than 15 cm.

[0162] The invention further provides a system with where the overage temperature ($T_w - T_s$) equal to or less than the following function

$$56353 \times Bo + 1.4315$$

from $Bo = 1.0E-06$ to $1E-04$, for 3 or more channels, and where the average maximum flux to minimum heat flux ratio of 3:1 or greater and the each channel's length is at least 15 cm (preferably greater than 20 cm). Alternatively, the Overage temperature can be defined as equal to $4.84E9 \times SR \text{ number} + 2.15C + / - 2C$ for boiling in a microchannel.

[0163] The invention also provides apparatus for controlling partial boiling in mini or microchannels. In a preferred embodiment the apparatus comprises a pressure controller and/or a stabilizer located down stream of a channel or array of channels.

[0164] The invention also provides a method (or system) for controlling temperature in an array of channels in a device having an array of process channels adjacent to an array of partial boiling channels, comprising passing a fluid into a manifold and from the manifold into an array of heat exchange channels that are adjacent to an array of process channels that comprise an exothermic process. The flow of heat exchange fluid is controlled so that flow into the heat exchange channels varies to correspond to a varying heat output by the channels in the array of process channels. The flow into the heat exchange channels is controlled to provide stable partial boiling in the array of heat exchange channels that receive a varying amount of heat. In a preferred embodiment the array of heat exchange channels are cross-flow with respect to the array of process channels. One example of this system is illustrated in example 12.

[0165] Shear stress in the direction of velocity, u , may be calculated by the formula $F_x = \mu \cdot du/dy$, where μ is viscosity, and du/dy is the velocity gradient for the liquid flow normal to the microchannel wall. However, as in a location of liquid (represented by a control element) the velocity generally has three components, and shear stress also has three components. For a channel flow near and at the surface, a one dimensional assumption can be made and F_x can approximate the net shear at an element surface of the liquid. The use of computational fluid dynamics, including commercial software packages such as Fluent or FEMLAB, may be used to solve the required transport equations such that the surface shear force may be calculated. The surface shear stress may be calculated along the channel length, parallel to the direction of flow. Shear stress at the wall may also be calculated between parallel channels, where flow distribution effects are included to determine the mass flux into each parallel channel as a function of the detailed channel and manifold geometry. Additional calculation methods can be found, for example, in "Fundamentals of Fluid Mechanics," 3rd Ed., B. R. Munson, D. F. Young and T. H. Okiishi, John Wiley & Son, Inc., Weinheim, 1998.

[0166] In one embodiment, the shear force or stress deviation factor (SFDF) for a process employing a single process microchannel may be within about 50% of the SFDF for a scaled-up process involving multiple process microchannels. SFDF may be calculated using the formula $SFDF = (F_{max} - F_{min}) / (2F_{mean})$ wherein: F_{max} is the maximum shear stress in a process microchannel for a specific fluid; F_{min} is the minimum shear stress in the process microchannel for the fluid; and F_{mean} is the arithmetic average shear stress for the fluid at the microchannel wall surface. Within a single process microchannel, operated in accordance with the inventive process, the SFDF may be less than about 2, and in one embodiment less than about 1, and in one embodiment less than about 0.5, and in one embodiment less than about 0.2.

[0167] In one embodiment, the inventive process may provide for a relatively uniform shear stress while employing multiple process microchannels. To measure the shear stress uniformity among multiple process microchannels, the average shear stress is calculated for each channel and compared. F_{max} is the largest value of the average channel shear stress, and F_{min} is the smallest value of the average shear stress. F_{mean} is the mean of the average shear stresses of all the channels. SFDF may be calculated from these values. Among multiple process microchannels, at least with